PATENT
Attorney Docket No.: SSI-00700

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Group Art Unit: 1763
Maximilian A. Biberger et al.	Examiner: Rám N. Kackar
Serial No.: 09/704,641	**DECLARATION OF DR. MEHRDAD MOSLEHI UNDER 37 C.F. R. § 1.132 TO OVERCOME REJECTIONS UNDER 35 U.S.C. § 112, ¶ 1, AND 35 U.S.C. § 103**
Filed: November 1, 2000	
For: **METHOD AND APPARATUS FOR SUPERCRITICAL PROCESSING OF A WORKPIECE**	

Assistant Commissioner for Patents
Washington, D.C. 20231

I, Mehrdad Moslehi, state:

1. I make this declaration support of a response to an Office Action mailed April 3, 2002, in Patent Application Serial Number 09/704,641, titled "Method and Apparatus for Supercritical Processing of a Workpiece" (the "'641 patent application"), and filed November 1, 2000 (the "filing date").

2. I received a Master of Science in Electrical and a Ph.D. in Electrical Engineering in 1983 and 1986, respectively, from Stanford University, specializing in semiconductor integrated circuit technologies. I am a Senior Member of IEEE, as well as a member of the Electrochemical Society, the Materials Research Society, and the American Physical Society.

3. Over the past 22 years, I have worked at several high-technology semiconductor and micro electronic companies and research centers, including ITRC, Honeywell/Synertek, GE/Intersil, Xerox PARC, Texas Instruments, CVC Products, Veeco Instruments, and SemiZone, Inc.

4. While at TI, I served as a branch manager at TI's Semiconductor Process and Device Center. I was a key leader and contributor of TI's Microelectronics Manufacturing Science and

Technology (MMST) program which produced the world's first all-single-wafer semiconductor fab and 3-day cycle time for 0.35 μm CMOS IC manufacturing.

5. At Veeco Instruments and CVC Products I served as Senior Vice President and Chief Technology Officer in charge of product RD&E and technology development programs. As part of my duties, I oversaw research and product development in semiconductor device processing and the related manufacturing tools, such as cluster tool processing chambers.

6. I am the founder, chairman, and CEO of SemiZone, Inc., a company founded in partnership with the Stanford Center for Professional Development. SemiZone is an online learning resource providing educational and training courses for those in the semiconductor and related industries. Our courses cover semiconductor materials, equipment, processes, devices, design, and manufacturing technologies. As part of my duties helping to organize the courses offered at SemiZone and the topics that those in the semiconductor industry are most interested in, I keep current on semiconductor device technologies and semiconductor device fabrication. At SemiZone we have also developed a wide range of courses on various device processing technologies and related fabrication tools, including cluster tools.

7. For over the past 12 years I have been serving as a Consulting Faculty Member in the Electrical Engineering Department of Stanford University. In this role I have also advised Phd students and have served on their committees. I have consulted on a range of areas, including semiconductor technologies and semiconductor device fabrication, including semiconductor fabrication tools such as cluster tools. My primary area of consultation has been semiconductor device process and manufacturing technologies.

8. At Stanford University, Texas Instruments, CVC Products, and Veeco Instruments, I either directly developed or managed the development of the following types of cluster modules: etch, deposition, plasma, cleaning, high-pressure thermal processing, rapid-thermal processing, and rapid-thermal chemical wafer deposition.

9. I am the named inventor or co-inventor of over 120 issued patents. Many of these patents are in the area of semiconductor device fabrication and tools used to fabricate semiconductor

devices, including low-, atmospheric-, and high-pressure processing chambers or chamber components, manufacturing tools, and methods.

10. I have written over 100 journal and conference papers on semiconductors and related fields. In 1993 I was awarded American Electronics Association's (AEA) 50th Anniversary Inventor-of-the-Year award for my contributions to the semiconductor industry.

11. Since 1981, my job responsibilities have required that I keep up-to-date with current semiconductor processing technologies and manufacturing, including semiconductor processing chambers and cluster tools.

12. Before signing this declaration, I reviewed the following documents:

- the '641 patent application;
- the Office Action, mailed April 3, 2002;
- U.S. Patent Number 5,979,306, titled "HEATING PRESSURE PROCESSING APPARATUS," to Fujikawa et al. ("Fujikawa");
- U.S. Patent Number 6,110,232, titled "METHOD FOR PREVENTING CORROSION IN LOAD-LOCK CHAMBERS," to Chen et al. ("Chen");
- U.S. Patent Number 5,882,165, titled "MULTIPLE CHAMBER INTEGRATED PROCESS SYSTEM," to Maydan et al. ("Maydan"); and
- U.S. Patent Number 5,928,389, titled "METHOD AND APPARATUS FOR PRIORITY BASED SCHEDULING OF WAFER PROCESSING WITHIN A MULTIPLE CHAMBER SEMICONDUCTOR WAFER PROCESSING TOOL," to Jevtic ("Jevtic").

Collectively, I refer to Fujikawa, Chen, Maydan, and Jevtic as the "cited prior art."

13. As I describe in greater detail below, the specific engineering problems and issues associated with vacuum-integrated or atmospheric cluster tools, as disclosed in the cited prior art,

are substantially different from the design considerations and problems associated with specialized cluster tools that combine a high-pressure supercritical processing module and a low-pressure (or sub-atmospheric pressure) non-supercritical processing module, as disclosed in the '641 patent application.

14. To my knowledge, on the filing date, there were no commercial cluster tool systems that included the features and claimed elements disclosed in the '641 patent application. The '641 patent application clearly discloses the key engineering and operational issues associated with integrating a supercritical processing module and a non-supercritical processing module on a common transfer module; moreover, the '641 patent application discloses specific integration solutions. On the filing date, these solutions were not known and would not have been known to one skilled in the art. Indeed, no such device or tool is available today.

15. As I describe in more detail below, none of the cited prior art offers any teaching, suggestion, or motivation to combine them, as suggested by the Examiner, to produce the apparatus and methods disclosed in the '641 patent application. In addition, none of the cited prior art discloses the supercritical processing apparatus and method described in Figures 3 and 5 of the '641 patent application.

16. The '641 patent application discloses an apparatus and a method for cluster tool integration of a high-pressure supercritical processing chamber with a non-supercritical process module for automated integrated processing of a workpiece. The apparatus and method use a sequence of at least two different processing steps without exposing the workpiece to the atmospheric environment. The chamber is high-pressure in that during wafer processing, the pressure is substantially above atmospheric pressure; the processing chamber is supercritical in that it is a specialized high-pressure processing module used for supercritical cleaning of a workpiece such as a silicon wafer in a mixture of supercritical CO_2 and a suitable solvent additive; the workpiece may be, for example, a silicon wafer. Moreover, the '641 patent application discloses the apparatus for a supercritical CO_2 processing module and the related method for supercritical CO_2 cleaning of a workpiece such as a silicon wafer, where the cleaning action may also involve a photoresist strip action. The '641 patent application teaches how to

reliably integrate high-pressure (supercritical) and low-pressure (non-supercritical) processing modules on a cluster tool platform.

17. Because the supercritical processing module recited in claim 1 processes the workpiece at substantially above the atmospheric pressure (typically at many tens of atmospheres) and the non-supercritical processing module generally processes the workpiece at near vacuum or sub-atmospheric pressures (typically a low-pressure etch or a deposition process), this cluster tool essentially must have a substantially different design compared to the vacuum-integrated cluster tools referenced in the cited prior art. For example, the use of a buffer or isolation chamber (or an ante-chamber) located between the supercritical processing module and the transfer module (or wafer handling module) may be used to eliminate any detrimental impact of the supercritical process module on the nonsupercritical process module, enable operation of the cluster modules (supercritical process module and non-supercritical process module) at substantially different pressures, and improve the processing throughput. The use of an ante-chamber is properly described in the specification and covered in the dependent Claim 18. There is no ante-chamber in any of the cited prior art.

18. Fujikawa (U.S. Patent No. 5,979,306) discloses a stand-alone high-pressure/high-temperature (so-called heating pressure) process chamber used in such applications as oxidation, nitridation, or "washing by use of a fluid in super-critical state." Fujikawa describes the sealing and cooling requirements for a pressurized process chamber in order to eliminate the possibility of gas leakage or failure of the pressure seals due to heat. Fujikawa teaches a high-pressure apparatus for thermal processing of a workpiece. Fujikawa describes the means for pressurizing the process chamber with a process gas. However, Fujikawa does not describe or disclose any specific method for supercritical processing of a workpiece. The apparatus in Fujikawa is a stand-alone process unit. Fujikawa does not describe or teach integrating this process equipment on a cluster tool platform, nor does it mention integration of this high-pressure apparatus with a non-supercritical process module on a cluster tool platform. Indeed, simply attaching the device disclosed in Fujikawa to a vacuum chamber would not work.

19. Chen (U.S. Patent No. 6,110,232) discloses a method for preventing corrosion in a load-locked vacuum-integrated cluster tool. The method includes removing corrosive residues left on a wafer during a reactive-ion etch (RIE) or plasma etch process step by a post-etch insert gas purge/heat treatment of the processed wafer in a cluster-integrated degas chamber before the wafer is transferred back to the load-lock chamber attached to the cluster tool. Thus, the method disclosed in Chen eliminates the corrosion problem associated with the vacuum load-lock chambers as a result of the etch-induced corrosive residues left on the wafers. The method works by moving the etched wafer from the plasma etch cluster module to the degas cluster module and performing an insert gas purge/heat cycle on the wafer to remove the residual contaminants before it is moved back to the vacuum load-lock chamber. All of these steps are done at near vacuum (sub-atmospheric) pressures. Chen does not disclose any cluster tool apparatus; nor does Chen disclose any pressurized supercritical processing cluster tool. Chen does not mention supercritical processing. Simply combining Chen with the supercritical processing module would not work.

20. Maydan (U.S. Patent No. 5,882,165) discloses improvements to vacuum-integrated cluster tools used in semiconductor manufacturing. Maydan teaches a cluster tool that integrates several vacuum (sub-atmospheric) process modules and vacuum load-lock modules around a vacuum central wafer handler (or a vacuum transfer chamber). Maydan discloses a vacuum processing system (cluster tool) comprising at least two vacuum processing chambers (thus, both non-supercritical process modules) mounted on a vacuum transfer chamber with a workpiece-handling robot and an internal elevator. Maydan is exclusively a vacuum-integrated cluster tool and does not have any reference to a supercritical processing module. The cluster tool disclosed in Maydan is only suitable for non-supercritical process modules. Maydan's cluster tool cannot be used for mounting a supercritical process module. Simply attaching the device taught in Fujikawa with the one taught in Maydan would not work.

21. Jevtic (U.S. Patent No, 5,928,389) discloses an apparatus and method for priority-based scheduling for sequencing wafer processing events in a cluster tool system. The main purpose of the sequencer is to maximize the productivity and throughput of the cluster tool system. The reference cluster tool disclosed in Jevtic is a staged-vacuum Endura commercial cluster tool system from Applied Materials. Jevtic is generally directed to priority-based scheduling of

multiple process steps in a cluster tool. Jevtic does not disclose a cluster tool with supercritical and non-supercritical process modules. Moreover, Jevtic does not mention a supercritical processing apparatus or method. Simply attaching the devices taught in Fujikawa, Chen, and Jevtic would not work.

22. Within the Office Action, the Examiner rejected claims 1-25 and 29-30 under 35 USC § 112 first paragraph, stating that "the applicant has not disclosed the structural requirements for high pressure, seals and fittings and fixturing for work piece holding needed for connecting the supercritical module to [the] transfer module."

23. On the filing date (November 1, 2000), a person who was skilled in the art and had read the '641 patent application would have known the structural requirements for making the high-pressure process chambers (pressurized vessels) disclosed in the '641 patent application. After reading the '641 patent application the person would know how to choose and assemble the seals, fittings, and workpiece fixturing that form the process chambers and cluster tool described in the '641 patent application. To do this, one skilled in the art needs only the operating pressure and temperature ranges, as are disclosed, for example, at pages 9-10 of the '641 patent application.

24. High-pressure process chambers were known to those skilled in the art on the filing date, and were even manufactured then (e.g., Fujikawa). As another example, Gasonics (recently acquired by Novellus) introduced a commercial high-pressure thermal processing system for high-pressure oxidation applications over 17 years ago. In addition, between 1988 and 1994 as part of its Microelectronics Manufacturing Science and Technology (MMST) program, Texas Instruments developed (in collaboration with Gasonics) a single-wafer high-pressure thermal processing process module capable of mounting on or connecting to a wafer transfer chamber. However, none of these prior art chambers contemplated a cluster tool that combined supercritical processing modules, or even high-pressure modules, with low-pressure modules.

25. While none of these high-pressure processing systems were designed for or were suitable for supercritical process applications, the structural design requirements for the non-supercritical

and supercritical high-pressure processing systems are essentially similar. Techniques known on the filing date could have been used to specify the appropriate sealing, fitting, fixturing, and structural requirements for the supercritical processing module disclosed in the '641 patent application. Using these techniques, one skilled in the art can take the temperature and pressure that a processing chamber must withstand, and from these determine the appropriate sealing, fitting, fixturing, and structural requirements for the supercritical processing module. SSI's patent application discloses the operating temperature and pressure ranges of the supercritical processing module. Therefore, on the filing date, one skilled in the art would have been able to design the fittings, seals, process chamber structural requirements and the fixturing for connecting the supercritical process module to the transfer module to withstand the combination of specified pressures and temperatures.

26. The '641 patent application has clearly identified the motivation for combining a supercritical and a non-supercritical processing chamber as recited in claims 1 and 29 of the '641 patent application. This motivation lies in the viewpoint of an integrated process flow comprising etching a photoresist patterned wafer, followed by stripping the photoresist and cleaning the wafer to remove the etch-induced and photoresist residues, followed by a deposition step, all performed in an integrated cluster tool environment without exposing the wafer to the ambient atmosphere, thus improving the overall processing cleanliness and throughput. Without this motivation, one skilled in the art would not be inclined to integrate two vastly different processing modules (in terms of operating pressures) on one cluster tool platform since this type of integration presents special engineering challenges in terms of cross-contamination and throughput. The '641 patent application has clearly presented the motivation behind such cluster tool integration and the means/methods to provide cleanliness, eliminate cross contamination, and improve throughput.

27. The Examiner rejected claims 1 and 29 under 35 U.S.C. § 103(a) as being unpatentable in light of Chen combined with Fujikawa. Essentially the Examiner takes the prior art cluster tool of Chen comprising non-supercritical processing modules and combines it with the stand-alone heat pressure (supercritical) processing equipment of Fujikawa to arrive at a cluster tool similar to the apparatus recited in claim 1 of the '641 patent application. Chen does not disclose any

novel cluster tool apparatus. It merely discloses a method of preventing corrosion of the vacuum load-lock chambers due to the corrosive etching gases used in a cluster etch module. Chen discloses an Applied Materials vacuum-integrated cluster tool which is designed and only suitable for vacuum processing modules (non-supercritical processing modules). The stand-alone heating pressure processing apparatus of Fujikawa is not disclosed as a cluster module. While Fujikawa only briefly mentions the supercritical processing application of the module, it does not disclose the means and operating conditions to establish supercritical processing conditions. Unless someone skilled in the art is aware of the supercritical processing module apparatus and method disclosed in the '641 patent application, the combination of Fujikawa's heat pressure processing module and Chen's cluster tool would fail due to massive cross contamination and gas leakage between the supercritical processing and nonsupercritical processing modules. Further, combining the vacuum cluster tool of Chen with the supercritical module of Fujikawa is not possible and would result in an inoperative system.

28. The idea of integrating a pressurized (high-pressure) supercritical processing module with a (low-pressure or sub-atmospheric) non-supercritical processing module on a common transfer module would not have been obvious to one skilled in the art on the filing date. Such an integration of two processing modules with substantially different operating pressure regimes (the supercritical module operating at tens to well over 100 atmospheres while the non-supercritical module operating at sub-atmospheric and/or near-vacuum pressures) on a common transfer module requires identifying the supporting integrated process sequences that would benefit from such a cluster integration. The '641 patent application has clearly identified and disclosed such cluster-integrated process applications (for instance, etching the wafer in an etch module, stripping the photoresist and/or cleaning the wafer in a supercritical CO_2 cleaning module, and then depositing a metal layer in a non-supercritical metal deposition module). Moreover, the integration of such vastly different processing modules operating at substantially different pressure regimes on a common transfer module requires taking special precautions and utilizing features to eliminate the possibility of cross-contamination and gas leakage from the supercritical processing module to the nonsupercritical processing module(s) while achieving high processing throughputs.

29. Such precautions and features would not have been obvious to someone skilled in the art on the filing date. The '641 patent application clearly discloses the required apparatus (e.g., Figure 5) and supercritical processing method (e.g., Figure 3) to enable such high-throughput cluster integration of the supercritical processing module with non-supercritical processing modules on a common transfer module. On the filing date, one skilled in the art would not have tried to integrate Fujikawa's heat-pressure processing apparatus with Chen's vacuum-integrated cluster tool, without a knowledge of the required supercritical processing apparatus design features (Figure 5) and operating sequence (Figure 3) disclosed in the '641 patent application. Such an attempt would certainly fail due to massive cross-contamination and leakage problems.

30. In sum, there is no suggestion to combine Fujikawa with Chen to produce a cluster tool having a supercritical processing module and a non-supercritical processing module as recited in claims 1 and 29. Moreover, given the unique operational problems of supercritical and non-supercritical processing, there was no motivation or expectation of success to combine Fujikawa with Chen to produce the apparatus recited in claims 1 and 29. On the filing date, only by reading the '641 patent application would one skilled in the art know how to produce the apparatus recited in claims 1 and 29.

31. Another feature disclosed in the '641 patent application is the use of an ante-chamber (dependent claim 18) as an isolation or buffer chamber separating the supercritical module from the transfer chamber. This will further eliminate the chance of cross-contamination and leakage from the supercritical processing module to the non-supercritical processing modules.

32. The Examiner has rejected Claim 18 (the ante-chamber) as being unpatentable over Chen combined with Fujikawa and Jevtic. This rejection is based on the mistaken assumption that the Applied Materials Endura staged vacuum cluster tool platform disclosed in Jevtic can be used to mount a supercritical processing module. The assumption is that the transfer chamber 112 illustrated in Figure 1 of Jevtic can function as an antechamber. This assumption would not have been obvious to one skilled in the art for a number of reasons. First, the Applied Materials Endura system in Jevtic is a staged vacuum cluster tool system and there is no mention of using the second handler as an antechamber for supercritical processing modules. An ante-chamber or

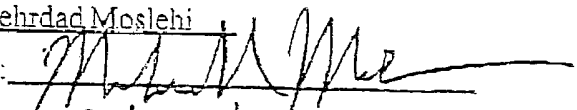
buffer/isolation chamber as outlined in the '641 patent application is a very small volume chamber connected to only one supercritical processing module on one end, while connecting to the transfer chamber on the other end. The requirement of a small volume is essential for maximizing throughput and minimizing cross-contamination between the supercritical processing module and other non-supercritical processing modules. The transfer chamber 112 in Jevtic (Endura's staged vacuum central wafer handler) fundamentally does not meet the requirements for a supercritical processing ante-chamber since (a) it has a very large volume, (b) it has multiple access ports, and (c) it does not meet the low-volume requirement for fast throughput and negligible cross-contamination. Thus, on the filing date, it would not have been obvious to one skilled in the art to combine Jevtic, Chen, and Fujikawa to produce a cluster tool having supercritical modules, non-supercritical modules, and an ante-chamber since the resulting outcome falls far short of meeting the intended requirements (reduced cross-contamination and increased throughput). If one skilled in the art used Jevtic's cluster tool and attached Fujikawa's processing system to it by using the staged transfer chamber as an ante-chamber, the combined system would not be practical for manufacturing applications.

33. The Examiner has rejected Claim 30 as being unpatentable in light of Maydan combined with Fujikawa. Again, Maydan's cluster tool is a vacuum-integrated cluster tool which is not capable of supporting a combination of supercritical and non-supercritical processing modules. In fact, Maydan only mentions vacuum-integrated processing and does not mention any pressurized supercritical processing. Moreover, Fujikawa's heat pressure system is a stand-alone high-pressure processing system and nowhere does Fujikawa envision or disclose clustering of its module or cluster integration of the system with a non-supercritical processing module. Fujikawa does not disclose any supercritical processing or cleaning methods. The combination of Maydan's cluster tool and Fujikawa's heat pressure processing system also falls far short of the claimed cluster integrated system comprising supercritical processing and non-supercritical processing modules. A direct integration of Fujikawa's heat pressure processing system on Maydan's cluster tool will not provide the result produced by the apparatus recited in claim 30 of the '641 patent application. Again combining a supercritical processing module and a non-supercritical processing module on a cluster tool platform would not have been obvious to one skilled in the art on the filing date without the process integration drivers being identified, as in

the '641 patent application. The combination of Maydan and Fujikawa does not teach how to perform supercritical cleaning or how to conduct a sequence of supercritical and non-supercritical process steps. Without a knowledge of the process apparatus of Figure 5 and the process sequence in Figure 3 of the '641 patent application, the combination of Maydan and Fujikawa on a cluster platform would fail; the cluster tool disclosed by Maydan would not operate properly in combination with Fujikawa's system and there would be massive cross-contamination and leakage between different modules. The cluster tool would simply fail and not operate properly.

34. In sum, there is no suggestion to combine Maydan with Fujikawa to produce the apparatus recited in claim 30. Moreover, given the unique operational problems of supercritical and non-supercritical processing, there was no motivation or expectation of success to combine Maydan with Fujikawa with to produce the apparatus recited in claim 30. On the filing date, only by reading the '641 patent application would one skilled in the art know how to produce the apparatus recited in claim 30.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent that issues from it.

Name: Mehrdad Moslehi
Signature: 
Date: 9/23/02
Country of Citizenship: U.S.A.
Residence: 956 Stanley Avenue
Los Altos, California 94024